What is claimed is:

1. An aberration compensating optical element comprising:

a diffractive structure having a plurality of ring-shaped zone steps formed on at least one surface of the aberration compensating optical element;

wherein the aberration compensating optical element is adapted for being disposed on an optical path between a light source for emitting a light having a wavelength of not more than 550nm, and an objective lens made of a material having an Abbe constant of not more than 95.0 at a d-line; and

wherein the following inequality is satisfied:

$P_{\lambda 1} < P_{\lambda 0} < P_{\lambda 2}$,

where $P_{\lambda 0}$ is a paraxial power (mm^{-1}) of the aberration compensating optical element at the wavelength λ_0 of the light emitted from the light source;

$P_{\lambda 1}$ is a paraxial power (mm^{-1}) of the aberration compensating optical element at a wavelength λ_1 which is 10nm shorter than the wavelength λ_0; and

$P_{\lambda 2}$ is a paraxial power (mm^{-1}) of the aberration compensating optical element at a wavelength λ_2 which is 10nm longer than the wavelength λ_0.

2. An aberration compensating optical element comprising:

a diffractive structure having a plurality of ring-shaped

zone steps formed on at least one surface of the aberration compensating optical element;

wherein the aberration compensating optical element is adapted for being disposed on an optical path between a light source for emitting a light having a wavelength of not more than 550nm, and an objective lens made of a material having an Abbe constant of not more than 95.0 at a d-line; and

wherein at least one ring-shaped zone step having a step distance Δ (mm) in a direction of an optical axis between adjacent steps of the plurality of ring-shaped zone steps is formed within an effective diameter so that m defined by following equations:

$m = INT(Y)$,

$Y = \Delta \times (n-1)/(\lambda_0 \times 10^{-3})$,

is an integer except 0 and ±1,

where INT(Y) is an integer obtained by rounding Y, λ_0 is the wavelength (nm) of the light emitted from the light source, and n is a refractive index of the aberration compensating optical element at the wavelength λ_0 (nm).

3. An aberration compensating optical element comprising:

a diffractive structure having a plurality of ring-shaped zone steps formed on at least two surfaces of the aberration compensating optical element;

wherein the aberration compensating optical element is adapted for being disposed on an optical path between a light

source for emitting a light having a wavelength of not more than 550nm, and an objective lens made of a material having an Abbe constant of not more than 95.0 at a d-line.

4. An aberration compensating optical element comprising:

a single lens;

wherein the single lens has one optical surface having a diffractive structure having a plurality of ring-shaped zone steps formed on a plane surface and another optical surface opposite to the one optical surface, which has a concave refractive surface; and

wherein the aberration compensating optical element is adapted for being disposed on an optical path between a light source for emitting a light having a wavelength of not more than 550nm, and an objective lens made of a material having an Abbe constant of not more than 95.0 at a d-line.

5. The aberration compensating optical element of claim 1; wherein the following inequality is satisfied:

$$0.5\times10^{-2} < P_D < 15.0\times10^{-2},$$

where P_D is a paraxial power (mm^{-1}) of the diffractive structure and is defined by the following equation:

$$P_D = \Sigma(-2\cdot b_{2i}\cdot ni),$$

when an optical path difference function is defined by the following equation:

$$\Phi bi = ni \cdot (b_{2i} \cdot hi^2 + b_{4i} \cdot hi^4 + b_{6i} \cdot hi^6 + \cdots),$$

as a function that an optical path difference Φbi added to a wavefront transmitting through the aberration compensating optical element, by the diffractive structure formed on an i-th surface of the aberration compensating optical element, is expressed by using a height hi (mm) from the optical axis; where ni is a diffraction order of a diffracted light having a maximum diffracted light amount among a plurality of diffracted lights generated by the diffractive structure formed on the i-th surface, and b_{2i}, b_{4i}, b_{6i}, $\cdots$ are a second order coefficient of the optical path difference function, a fourth order one, a sixth order one $\cdots$, respectively.

6. The aberration compensating optical element of claim 5; wherein the following inequality is satisfied:

$$1.0\text{x}10^{-2} < P_D < 10.0\text{x}10^{-2}.$$

7. An aberration compensating optical element comprising:

a diffractive structure having a plurality of ring-shaped zone steps formed on at least one surface of the aberration compensating optical element;

wherein the following inequality is satisfied:

$$1.0\text{x}10^{-2} < P_D < 10.0\text{x}10^{-2},$$

where P_D is a paraxial power (mm^{-1}) of the diffractive structure and is defined by the following equation:

$P_D = \Sigma(-2 \cdot b_{2i} \cdot ni)$,

when an optical path difference function is defined by the following equation:

$\Phi bi = ni \cdot (b_{2i} \cdot hi^2 + b_{4i} \cdot hi^4 + b_{6i} \cdot hi^6 + \cdots\cdot)$,

as a function that an optical path difference Φbi added to a wavefront transmitting through the aberration compensating optical element, by the diffractive structure formed on an i-th surface of the aberration compensating optical element, is expressed by using a height hi (mm) from an optical axis; where ni is a diffraction order of a diffracted light having a maximum diffracted light amount among a plurality of diffracted lights generated by the diffractive structure formed on the i-th surface, and b_{2i}, b_{4i}, b_{6i}, $\cdots\cdot$ are a second order coefficient of the optical path difference function, a fourth order one, a sixth order one $\cdots\cdot$, respectively.

8. The aberration compensating optical element of claim 1, wherein the paraxial power $P_{\lambda 0}$ of the aberration compensating optical element is substantially zero at the wavelength λ_0 of the light emitted from the light source.

9. The aberration compensating optical element of claim 8, wherein the following inequalities are satisfied:

$P_D > 0$

$P_R < 0$

$-0.9 < P_D/P_R < -1.1$,

where P_D is a paraxial power (mm^{-1}) of the diffractive structure and is defined by the following equation:

$$P_D = \Sigma(-2 \cdot b_{2i} \cdot ni),$$

when an optical path difference function is defined by the following equation:

$$\Phi b = ni \cdot (b_{2i} \cdot hi^2 + b_{4i} \cdot hi^4 + b_{6i} \cdot hi^6 + \cdots),$$

as a function that an optical path difference Φbi added to a wavefront transmitting through the aberration compensating optical element, by the diffractive structure formed on an i-th surface of the aberration compensating optical element, is expressed by using a height hi (mm) from an optical axis; where ni is a diffraction order of a diffracted light having a maximum diffracted light amount among a plurality of diffracted lights generated by the diffractive structure formed on the i-th surface, and b_{2i}, b_{4i}, b_{6i}, $\cdots$ are a second order coefficient of the optical path difference function, a fourth order one, a sixth order one $\cdots$, respectively: and

P_R is a refractive power (mm^{-1}) of the aberration compensating optical element as a refractive lens.

10. The aberration compensating optical element of claim 1, wherein the diffractive structure has such a spherical aberration property that a spherical aberration of an emergent light flux is changed in an under-corrected direction or an over-corrected direction when a wavelength of an incident light flux is shifted to a longer wavelength side;

wherein the diffractive structure is formed so as to satisfy the following inequality:

$0.2 \leqq |(P_{hf}/P_{hm})-2| \leqq 6.0$,

where P_{hf} is a first interval in a direction to perpendicular to an optical axis of the diffractive structure between adjacent steps of the ring-shaped zones of the diffractive structure at a diameter hf which is a half of a maximum effective diameter hm, and P_{hm} is a second interval in the direction to perpendicular to the optical axis of the diffractive structure between adjacent steps of the ring-shaped zones of the diffractive structure at the maximum effective diameter hm.

11. The aberration compensating optical element of claim 1, wherein when a wavelength of a light entering the diffractive structure is not more than 550nm, a diffraction efficiency of the diffractive structure becomes maximal.

12. The aberration compensating optical element of claim 1; wherein the aberration compensating optical element is a plastic lens.

13. An optical system for carrying out at least one of a record of information on an information recording surface of an optical information recording medium and a reproduction of information from the information recording surface; comprising:

a light source for emitting a light having a wavelength

of not more than 550nm;

an objective lens made of a material having an Abbe constant of not more than 95.0 at a d-line; and

the aberration compensating optical element of claim 1, which is disposed on an optical path between the light source and the objective lens.

14. An optical pickup device for carrying out at least one of a record of information on an information recording surface of an optical information recording medium and a reproduction of information from the information recording surface; comprising:

a condensing optical system having the optical system of claim 13.

15. A recorder for recoding at least one of a sound and an image, comprising the optical pickup device of claim 14.

16. A reproducer for reproducing at least one of a sound and an image, comprising the optical pickup device of claim 14.

17. An aberration compensating optical element comprising:

a plastic lens having a single lens structure, and comprising a diffractive structure having a plurality of ring-shaped zone steps formed on at least one surface of the

plastic lens;

wherein the aberration compensating optical element is adapted for being disposed on an optical path between a light source and an objective lens having an image-side numerical aperture of not less than 0.75 and comprising at least one plastic lens; and

wherein the aberration compensating optical element decreases a change $\Delta 3SA_{OBJ}$ in a third-order spherical aberration of the objective lens, which is caused by a refractive index change ΔN_{OBJ} of at least one plastic lens contained in the objective lens due to a temperature change of the objective lens, by using an inclination change of a marginal ray of an emergent light flux from the aberration compensating optical element, which is caused by a refractive index change ΔN_{AC} of the aberration compensating optical element due to a temperature change of the aberration compensating optical element.

18. The aberration compensating optical element of claim 17, wherein the following inequality is satisfied:

$P_{T1} < P_{T0} < P_{T2}$,

where P_{T0} is a paraxial power (mm^{-1}) of the aberration compensating optical element at a predetermined temperature T_0;

P_{T1} is a paraxial power (mm^{-1}) of the aberration compensating optical element at a temperature T_1 which is lower than the predetermined temperature T_0; and

P_{T2} is a paraxial power (mm^{-1}) of the aberration compensating

optical element at a temperature T_2 which is higher than the predetermined temperature T_0.

19. The aberration compensating optical element of claim 18, wherein the objective lens is one having a doublet lens structure in which a first lens having a positive refractive power and a second lens having a positive refractive power are arranged in an order from a side of the objective lens; and

wherein at least the first lens is a plastic lens.

20. The aberration compensating optical element of claim 19, wherein the following inequalities are satisfied:

$P_R < 0$

$0 < \Delta P_{AC}/\Delta T_{AC} < 1 \times 10^{-4}$,

where P_R is a refractive power (mm^{-1}) of the aberration compensating optical element as a refractive lens; and

ΔP_{AC} is an amount of a change in a paraxial power (mm^{-1}) of the aberration compensating optical element, which is caused by the temperature change ΔT_{AC} (°C) of the aberration compensating optical element.

21. The aberration compensating optical element of claim 19, wherein the light source is one for emitting a light having a wavelength of not more than 550nm; and

wherein the following inequality is satisfied:

$P_{\lambda 1} < P_{\lambda 0} < P_{\lambda 2}$,

where $P_{\lambda 0}$ is a paraxial power (mm^{-1}) of the aberration compensating optical element at the wavelength λ_0 of the light emitted from the light source;

$P_{\lambda 1}$ is a paraxial power (mm^{-1}) of the aberration compensating optical element at a wavelength λ_1 which is 10nm shorter than the wavelength λ_0; and

$P_{\lambda 2}$ is a paraxial power (mm^{-1}) of the aberration compensating optical element at a wavelength λ_2 which is 10nm longer than the wavelength λ_0.

22. The aberration compensating optical element of claim 19, wherein the following inequities are satisfied:

$|\Delta 3SA_{OBJ}|/|\Delta 5SA_{OBJ}| > 1$,

$-30.0\times10^{-4} < \Delta 3SA_{OBJ}/(\Delta T_{OBJ} \cdot NA^4 \cdot f_{OBJ}) < 0$,

$3\times10^{-2} < \Delta fB_{OBJ} \cdot \nu d_{OBJ}/f_{OBJ} < 14\times10^{-2}$,

$1.0\times10^{-2} < P_D < 10.0\times10^{-2}$,

where $\Delta 3SA_{OBJ}$ is a change in a third-order spherical aberration component of a Zernike polynomial into which an aberration of the objective lens is expanded, in case that a refractive index of the plastic lens in the objective lens is changed by ΔN_{OBJ} due to the temperature change ΔT_{OBJ} (°C) of the objective lens; the change in the third-order spherical aberration being expressed by a root mean square value by a wavelength λ_0 of a light emitted from the light source; and a sign of the change in the third-order spherical aberration being positive when the third-order spherical aberration component is changed in an

over-corrected direction, and being negative when the third-order spherical aberration component is changed in an under-corrected direction;

$\Delta 5SA_{OBJ}$ is a change in a fifth-order spherical aberration component of the Zernike polynomial into which the aberration of the objective lens is expanded, in case that the refractive index of the plastic lens in the objective lens is changed by ΔN_{OBJ} due to the temperature change ΔT_{OBJ} (°C) of the objective lens; the change in the fifth-order spherical aberration being expressed by a root mean square value by the wavelength λ_0 of a light emitted from the light source;

NA is a predetermined image-side numerical aperture which is required for at least one of a record of information on an optical information recording medium and a reproduction of information from the optical information recording medium;

f_{OBJ} is a focal length (mm) of the objective lens;

ΔfB_{OBJ} is an axial chromatic aberration (mm) occurring at the objective lens when a light having a wavelength which is +10nm longer than the wavelength λ_0 of a light emitted from the light source enters the objective lens;

νd_{OBJ} is a mean value of an Abbe constant of the first lens in the objective lens at the d-line and an Abbe constant of the second lens at the d-line; and

P_D is a paraxial power (mm^{-1}) of the diffractive structure and is defined by the following equation:

$P_D = \Sigma(-2 \cdot b_{2i} \cdot ni)$,

when an optical path difference function is defined by the following equation:

$$\Phi bi = ni \cdot (b_{2i} \cdot hi^2 + b_{4i} \cdot hi^4 + b_{6i} \cdot hi^6 + \cdots),$$

as a function that an optical path difference Φbi added to a wavefront transmitting through the diffractive structure formed on an i-th surface of the aberration compensating optical element, by the diffractive structure formed on the i-th surface, is expressed by using a height hi (mm) from an optical axis; where b_{2i}, b_{4i}, b_{6i}, $\cdots$ are a second order coefficient of the optical path difference function, a fourth order one, a sixth order one $\cdots$, respectively, and ni is a diffraction order of a diffracted light having a maximum diffracted light amount among a plurality of diffracted lights generated by the diffractive structure formed on the i-th surface.

23. The aberration compensating optical element of claim 17, comprising one optical surface having a diffractive structure having a plurality of ring-shaped zone steps formed on a plane surface and another optical surface opposite to the one optical surface, which has a concave refractive surface.

24. The aberration compensating optical element of claim 17, wherein a paraxial power $P_{\lambda 0}$ of the aberration compensating optical element is substantially zero at a wavelength λ_0 of a light emitted from the light source.

25. The aberration compensating optical element of claim 24, wherein the following inequalities are satisfied:

$P_D > 0$

$P_R < 0$

$-0.9 < P_D/P_R < -1.1$,

where P_D is a paraxial power (mm^{-1}) of the diffractive structure and is defined by the following equation:

$P_D = \Sigma(-2 \cdot b_{2i} \cdot ni)$,

when an optical path difference function is defined by the following equation:

$\Phi bi = ni \cdot (b_{2i} \cdot hi^2 + b_{4i} \cdot hi^4 + b_{6i} \cdot hi^6 + \cdots)$,

as a function that an optical path difference Φbi added to a wavefront transmitting through the diffractive structure formed on an i-th surface of the aberration compensating optical element, by the diffractive structure formed on the i-th surface, is expressed by using a height hi (mm) from an optical axis; where b_{2i}, b_{4i}, b_{6i}, $\cdots$ are a second order coefficient of the optical path difference function, a fourth order one, a sixth order one $\cdots$, respectively, and ni is a diffraction order of a diffracted light having a maximum diffracted light amount among a plurality of diffracted lights generated on the diffractive structure formed on the i-th surface; and

P_R is a refractive power (mm^{-1}) of the aberration compensating optical element as a refractive lens.

26. The aberration compensating optical element of

claim 17, wherein the following inequality is satisfied:

$P_{T2} < P_{T0} < P_{T1}$,

where P_{T0} is a paraxial power (mm^{-1}) of the aberration compensating optical element at a predetermined temperature T_0;

P_{T1} is a paraxial power (mm^{-1}) of the aberration compensating optical element at a temperature T_1 which is lower than the predetermined temperature T_0; and

P_{T2} is a paraxial power (mm^{-1}) of the aberration compensating optical element at a temperature T_2 which is higher than the predetermined temperature T_0.

27. The aberration compensating optical element of claim 26, wherein the objective lens is a plastic lens having a single lens structure.

28. The aberration compensating optical element of claim 17, wherein at least one ring-shaped zone step having a step distance Δ (mm) in a direction of an optical axis between adjacent steps of the plurality of ring-shaped zone steps is formed within an effective diameter so that m defined by following equations:

$m = INT(Y)$,

$Y = \Delta \times (n-1)/(\lambda_0 \times 10^{-3})$,

is an integer except 0 and ±1,

where INT(Y) is an integer obtained by rounding Y, λ_0 is the wavelength (nm) of the light emitted from the light source, and

n is a refractive index of the aberration compensating optical element at the wavelength λ_0 (nm).

29. The aberration compensating optical element of claim 17, comprising a plurality of diffractive structures having a plurality of ring-shaped zone steps formed on both surfaces of the aberration compensating optical element.

30. The aberration compensating optical element of claim 17, wherein the diffractive structure has such a spherical aberration property that a spherical aberration of an emergent light flux is changed in an under-corrected direction or an over-corrected direction when a wavelength of an incident light flux is shifted to a longer wavelength side;

wherein the diffractive structure is formed so as to satisfy the following inequality:

$0.2 \leqq |(P_{hf}/P_{hm})-2| \leqq 6.0$,

where P_{hf} is a first interval in a direction to perpendicular to an optical axis of the diffractive structure between adjacent steps of the ring-shaped zones of the diffractive structure at a diameter hf which is a half of a maximum effective diameter hm, and P_{hm} is a second interval in the direction to perpendicular to the optical axis of the diffractive structure between adjacent steps of the ring-shaped zones of the diffractive structure at the maximum effective diameter hm.

31. The aberration compensating optical element of claim 17, wherein when a wavelength of a light entering the diffractive structure is not more than 550nm, a diffraction efficiency of the diffractive structure becomes maximal.

32. An optical system for carrying out at least one of a record of information on an information recording surface of an optical information recording medium and a reproduction of information from the information recording surface; comprising:

a light source;

an objective lens having an image-side numerical aperture of not less than 0.75 and comprising at least one plastic lens; and

the aberration compensating optical element of claim 17, which is disposed on an optical path between the light source and the objective lens.

33. An optical pickup device for carrying out at least one of a record of information on an information recording surface of an optical information recording medium and a reproduction of information from the information recording surface; comprising:

a condensing optical system having the optical system of claim 32.

34. A recorder for recoding at least one of a sound and

an image, comprising the optical pickup device of claim 33.

35. A reproducer for reproducing at least one of a sound and an image, comprising the optical pickup device of claim 33.